The GENERAL RADIO EXPERIMENTER

VOL. 1 NO. 10 APRIL, 1927

New Tubes for Old

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An old Arabian legend tells how Aladdin, seeking to recover his magic but unpretentious-appearing lamp which had been unwittingly discarded by a servant, went to the market place, where he astonished the populace by offering to give away new lamps for old. In a like manner a modern Aladdin might offer to give new lamps (vacuum tubes) in exchange for old without deserving much credit as a philanthropist. All of which introduces us to the subject of the reactivation of vacuum tubes by the simple process of rejuvenating their filaments.

TYPE 388
VACUUM TUBE REACTIVATOR
An instrument for testing and restoring thoriated vacuum tubes

A large part of the vacuum tubes used in radio reception today have the so-called thoriated filaments. Chief among these are the Radiotrons: UV and UX-199, UX-120, UX-200-A, UX-201-A, UX-171, UX-210, UX-213 and UX-216-B; the Cunningham tubes: C and CX-299, CX-120, CX-300-A, CX-301-A, CX-371, CX-310, CX-313 and CX-316-B; and corresponding tubes from other manufacturers.

The electronic emission of these tubes, that is, their plate current, depends upon the presence of a layer of thorium atoms on the outer surface of the filament. The filament is not thorium-coated, however, after the manner of the oxide-coated filaments, but is, rather, permeated throughout its whole substance with this rare element, thorium. During the normal operation of these tubes the thorium on the outer surface of the filament gradually evaporates. This would correspondingly reduce the emission current and render the tube very short-lived were it not for the fact that the thorium is continuously replenished from the interior of the filament. As long as the filament voltage in normal use is not raised over ten percent above the rated value this evaporation and replenishing continues at an equilibrium rate, so that a constant layer of thorium is maintained on the surface.

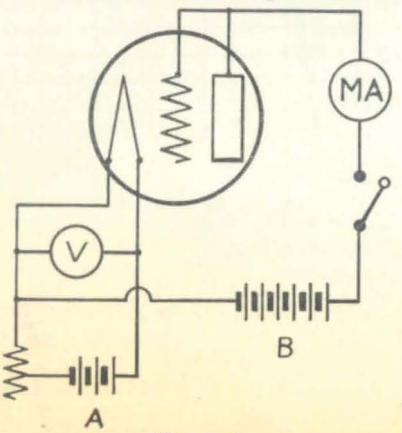

Figure 1

When subjected to an overvoltage on the filament, however, the evaporation becomes excessive so that the thorium surface layer is partially or completely diminished, and the tube accordingly more or less paralyzed. Operating these tubes at subnormal voltages is also liable to paralyze them slowly, as the filament temperature is then so low that the process of boiling out the thorium from the interior of the filament becomes abnormally retarded. Hence, it is important that the thoriated filament tubes be run at their rated filament voltages. It may be noted here that the maximum life of the "dry cell" tubes is attained when they are operated with a voltage of 3.3 across the filament.

While the great majority of thoriated tubes after a long and useful life gradually die a natural death, others are not infrequently executed by excessive voltages. In either case, if the filament is not actually burnt out, the chances are very good that the tube may be restored to life and vigor by the simple process of reactivation.

Before the cure we must diagnose the disease, and so before reactivation we should test the emission of the tube to ascertain if it is actually

Type of Tube		Fil. E. M. F.	Plate E. M. F.	Min. Emission
UV-199 C-299	UX-199 CX-299	3.3	50	6 m. a.
UX-120	CX-220	3.3	50	15 m. a.
UX-201A	CX-301A	5.0	50	25 m. a.
UX-200A	CX-300A	5.0	50	12 m. a.
UX-171	CX-371	5.0	50	50 m. a.
UX-210	CX-310	6.0	100	100 m. a.
UX-213	CX-313	4.0	100	50 per anode
UX-216B	CX-316B	6.0	125	100

below normal. To do this the circuit shown in Figure 1 is used. The grid and plate are tied directly together and then joined to the plus terminal of the B battery through a milliammeter. The negative B battery terminal is joined to the negative end of the filament and a key switch, normally open, is included in the plate circuit. The voltage across the filament, read on "V," should first be adjusted to the values specified in the table, which give also the proper values of B battery to use with the different tubes. These values should not be exceeded. Now depress the key just long enough to obtain a reading of the emission current on MA. (Disregard the change in voltmeter reading caused by the emission current.) If the emission current obtained under these conditions is zero, or any value less than the minimum specified in the table, the tube can doubtless be improved by reactivation. These values and the recommended voltages were taken from literature furnished by E. T. Cunningham, Incorporated.

Reactivation can advantageously be accomplished in two steps: the first known as "flashing" and the second as "cooking." In both of these processes the grid and plate of the tube should be **completely disconnected** from any external circuits.

For flashing three-volt tubes, a voltage of twelve is applied to the filament for a period of about one second. This will completely paralyze the tube as the surface layer of thorium is wholly evaporated, but the "boiling-out" process within the filament is expedited by the flashing to such a degree that, if the tube is now cooked with a voltage of four across the filament, the surface layer will be rapidly replaced, so that, in a few moments, the emission of the filament will come back to normal and the rejuvenated tube is ready for another long lease of life. A constant "cooking voltage" of four is permissible in this case because there is no emission current to expedite surface evaporation.

If a subsequent emission test shows that the filament failed to respond to this reactivation process it is evident that the tube has served its normal life or else has been so heavily overloaded that the vacuum has been impaired.

The five-volt tubes should be flashed for the same interval at eighteen volts on the filament and cooked at seven volts. Flashing is not recommended for the power amplifiers UX-210 or CX-310, or the rectifier tubes UX-213, CX-313, UX-216-B and CX-316-B. These tubes may, however, be reactivated merely by cooking them for longer intervals. The UX-213 or CX-313 at six volts and the others at nine volts on the filament.

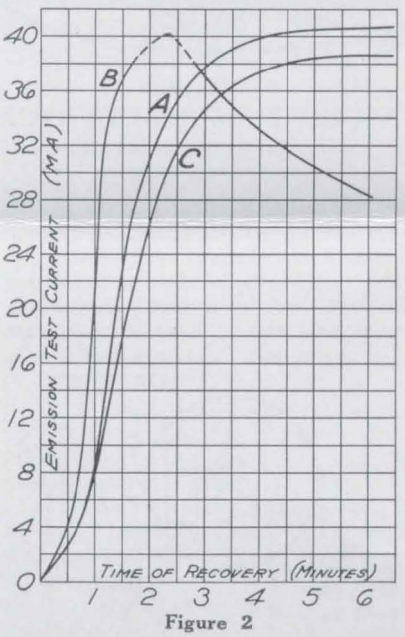

Figure 2

Curve A in Figure 2 shows the customary normal recovery of a UX-201-A tube while cooking at seven volts, after being flashed at eighteen volts. This recovery is slow at first, then increases rapidly, and finally slows down again as a saturation value is reached. When the tube was flashed at eighteen volts and then cooked at its rated filament voltage (five volts), the same saturation current was finally attained, but only after thirty-five minutes of cooking. Likewise recovery to the same saturation current, when cooked with four volts on the filament, required a period of two and one-half hours. On the other hand, cooking at nine volts on the filament caused a prompt recovery, but the saturation current was subsequently reduced, as shown in curve B, since, in this case, evaporation from the surface (even with no emission current) exceeded the boiling-out of thorium from the interior.

Curve C shows the recovery of the 201-A tube flashed at twelve volts and cooked at seven volts. The rate of recovery and final saturation values are seen to be slightly less than curve B, where the same tube was flashed at eighteen volts. It should be stated that the data for curve C were actually taken before the data for curve B, so that the results cannot be explained by a deterioration of the tube. Thus it is apparent that the recommended voltages for flashing and cooking should be used to secure best results.

It was found that tubes could, on the average, be flashed and recovered six or eight times before showing any decrease in the saturation current, which would indicate a deterioration of the filament. This deterioration, however, was not rapid, a dozen flashings serving to reduce the saturation current by only 8 or 10 percent. This does not mean, however, that the total life of a thoriated filament properly used may be increased tenfold by reactivation. Reactivation might be expected, perhaps, to triple the useful life of the tube.

Realizing the value to the experimenter and the dealer of a simple device for testing and reactivating tubes, the General Radio Company has developed the Type 388 Tube Reactivator which operates from 110-volt, 60-cycle A. C. No batteries or other equipment are necessary to the operation of this instrument. Sockets are provided whereby the correct voltage for testing, flashing, and "cooking" are automatically obtained without any adjustments whatever. The operation is, accordingly, extremely simple and the results quite satisfactory. The emission of the various oxide-coated filaments can likewise be tested on the Type 388 Tube Reactivator, but these tubes can not, of course, be reactivated.